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R-3 93-5

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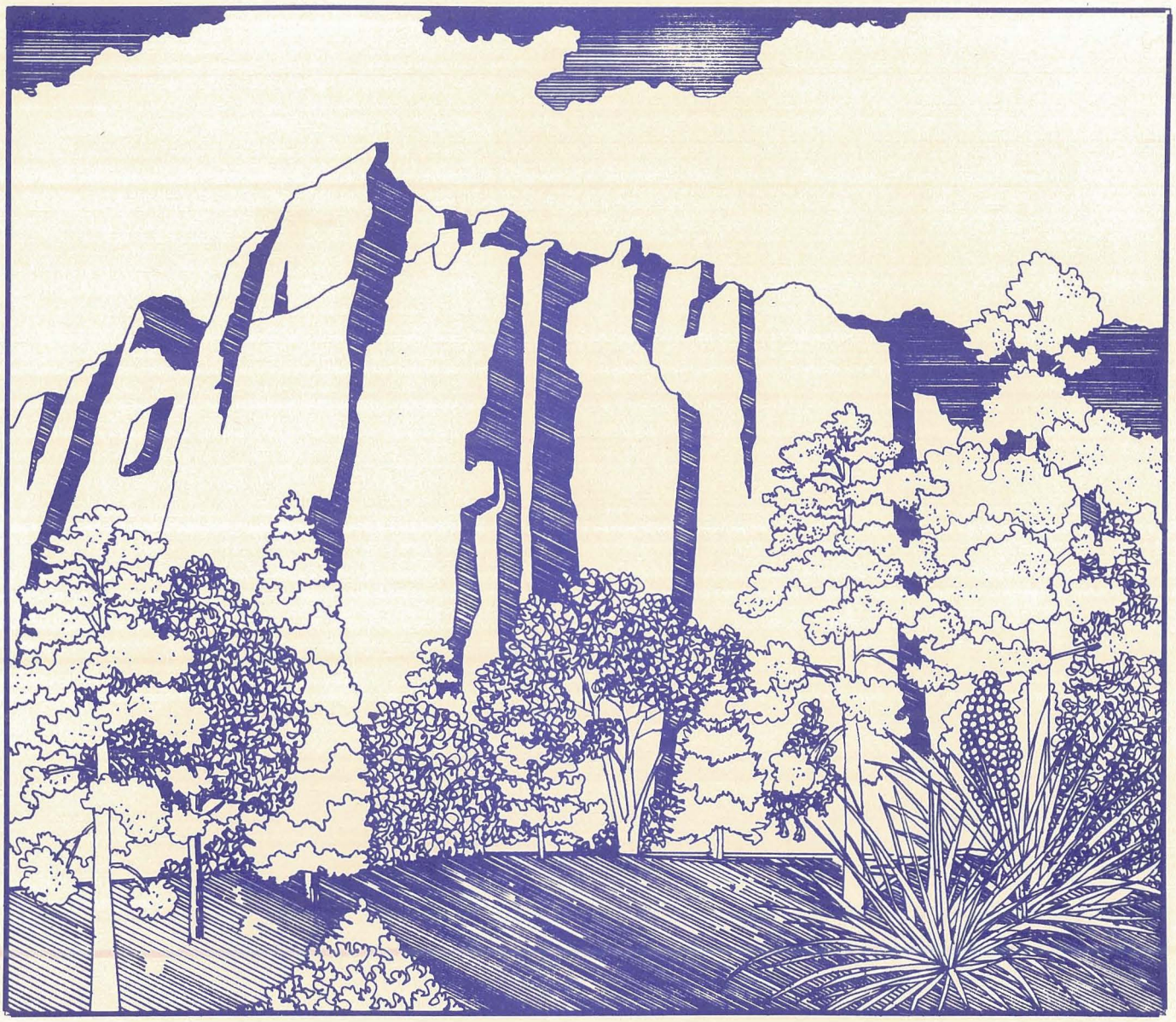

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BIOLOGICAL EVALUATION OF A PRESCOTT SCALE OUTBREAK ON THE FORT APACHE INDIAN RESERVATION, ARIZONA

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ABSTRACT

An outbreak of the Prescott scale, Matsucoccus vexillorum Morrison was evaluated in the White Mountains on the Fort Apache Indian Reservation in Arizona. Branch dieback, caused by the scale has been reported on the reservation for several years. Surveys were conducted to determine the current distribution and effects of the scale infestation. An intensive survey, conducted in a portion of the infested area, revealed that over half (54.5 percent) of the trees in the survey area displayed some degree of branch dieback. The most heavily affected size classes were those between 4 and 14 inches in diameter. Some trees (2.4 percent) were killed by the scale. On average, scale infested plots were denser than uninfested plots. Management alternatives and recommendations are discussed.

INTRODUCTION

Branch dieback of ponderosa pine, caused by the Prescott scale, Matsucoccus vexillorum Morrison, has been reported along Highway 260 in the vicinity of the Hawley Lake turnoff for several years. Surveys were conducted during July and August 1992 to estimate current distribution and effects of the scale infestation. Since no methods are known for estimating Prescott scale populations, this report will concentrate on describing current effects of the infestation. The purpose of this report is to describe current conditions, management alternatives, and provide technical information on Prescott scale.

METHODS

In July, the known infested area was outlined by Maury Williams, Forester, Bureau of Indian Affairs, Fort Apache Agency. An intensive survey was conducted in the area along Highway 260 (Figure 1) during July 1992. Within this area a systematic variable plot/fixed plot cruise was used to estimate current stand conditions, and levels of branch dieback caused by the scale. Plots were established at 1/4 mile intervals along drivable roads. At each stop, two sets of nested plots were located at two chain intervals from the road. At each point, a variable plot (30 basal area factor) and fixed plot (1/100 acre) were established. A total of 54 points were established. For all sample trees, species, diameter at breast height, height, tree condition (healthy, infested, or dead), cause and Hawksworth Dwarf Mistletoe Rating (DMR) were recorded. In addition, to determine effects of Prescott scale, a scale rating (SR) was devised to estimate the percent of the canopy showing branch dieback. The rating was estimated as follows:

Scale Rating	Percent Canopy Affected
0	0
1	1-25
2	26-50
3	51-75
4	76-100

from this information trees per acre (TPA) and square feet of basal area per acre (BA) were calculated by species, diameter class (DBH), tree condition, causal agent, DMR, and SR.

An extensive survey was conducted over a wider area during July and August to provide information on the distribution of branch dieback (Figure 2). A roadside survey was used for this purpose. Presence or absence of the scale was noted by an observer at quarter mile intervals while a vehicle was driven at low speeds. The roads surveyed were suggested by Maury Williams and included: Road 473 from Highway 260 to Hawley Lake, R26 between Road 473 and R27, R27 between R26 (near Pistol Butte) and the North fork White River crossing, and R76 between R27 and 473. United States Geological Survey topographic series maps, scale 1:24,000, were used to provide locations during the survey. The quads used included McNary, Horseshoe Cienaga, and Hawley Lake West.

RESULTS

Intensive survey

While less than five percent of the ponderosa pine regeneration was affected by branch dieback (Table 1), over half of the ponderosa pine trees (>5 inches DBH) in the survey area (54.5 percent of 203.5 TPA) have some degree of branch dieback caused by Prescott Scale (Table 2). The most heavily affected size classes are those between 4 and 14 inches DBH. Branch dieback was noted on 50 percent or greater of the trees in these size classes, except for the 12 inch class in which 46 percent of the trees were affected. Scale ratings were also higher for trees in these size classes (Table 3). Average ratings were highest for the 6 and 8 inch DBH classes (1.1). Ratings greater than 1 were not recorded for trees larger than 14 inches. The average rating for all trees was 1.0, while for infested trees only it was 1.8. A few trees were apparently killed by the scale, 2.4 percent overall, or 4.8 TPA (Table 2). These were found in the 6 and 10 inch diameter classes.

The distribution of branch dieback in the survey area was clumpy. Branch dieback was observed on 32 of 54 plots. Within infested plots, branch dieback was observed on 70.8 percent of the trees (Table 4). On average, the infested plots were denser than uninfested plots, 266.8 TPA and 147.3 BA for infested vs 114.5 TPA and 106.4 BA for uninfested plots (Tables 4 and 5). In addition infested plots contained a somewhat higher percentage of trees (93 percent) in the 4-14 inch diameter range than the uninfested plots (81 percent). Overall, nearly half of the ponderosa pine BA is affected (Table 6).

Low levels of dwarf mistletoe were detected during the survey. The average DMR for the survey area was 0.1, 3 percent of the trees are infected.

Roadside Survey

Branch dieback, caused by Prescott scale, seems widely distributed in this part of the reservation (Figure 3). It was observed along Road R27 from the vicinity of Pistol Butte to the intersection of R27 with R47 (McKays Lookout Road), south of McKay's Peak. Branch dieback was observed on a few trees along the McKays Lookout Road, within a mile of its intersection with the R27 Road. Branch dieback was also observed along a section of R76 from the vicinity of its intersection with R76A to its intersection with 76D.

DISCUSSION

Prescott scale appears to be widely distributed in this area on the reservation within the ponderosa pine type. This is not surprising since the scale has been reported to occur throughout the southwest, causing sporadic and localized outbreaks of branch dieback. The most severely affected area seems to be the area that lies along highway 260 between Bog Creek and the Hawley Lake turnoff. Branch dieback was not observed as often in ponderosa pines within the mixed conifer type and the most severe branch dieback seems confined to areas where ponderosa pine predominates. The scale is affecting trees of all size classes, but branch dieback is most severe in small to medium size trees (6-8 inches). Within the generally affected area, the distribution of branch dieback was clumpy. Plots with branch dieback were much denser than those without. This suggests that stand density may be associated with branch dieback. In previous studies of Prescott scale it was reported that flagging usually occurs on trees less than 75 years old and is most conspicuous in dense stands of saplings or seedlings.

Factors affecting populations of Prescott scale are not well understood. Few natural enemies are known outside of a species of ladybird beetle and a green lacewing. It was the opinion of previous authors that have studied this insect that the principal factor in natural control is branch dieback, since the scales infesting the fading branches cannot survive once their host is dead. Previous studies report no important relation between flagging and tree vigor or site, however, they did mention that periods of severe twig killing were correlated to some extent with drought. Relationships between stand conditions, density, species composition, structure, etc. were not investigated in previous studies, however, this survey suggests a relationship between stand density and branch dieback may occur. Since the scale is not a very mobile insect, dispersal occurs primarily through the crawlers or mature females (see technical information), it would make sense that tree to tree dispersal might be easier in a denser stand. The potential importance of genetic resistance is also unknown, but has been suggested to be an important factor among sessile herbivores such as the Prescott scale. Research has shown that with some scale insects, populations become adapted to individual host trees forming what are called demes, whose survival ability on other trees is reduced (Cobb and Whitham 1993).

For these reasons, it is difficult to predict outbreak trends with this insect. Previous episodes of branch dieback have lasted several years. An outbreak on the Prescott National Forest in the 1930's lasted about 9 years and covered 30,000 acres during its peak. A 4 year drought coincided with this outbreak. An outbreak on the Chevelon Ranger District, Apache-Sitgreaves National Forests during the late 80's lasted several years as well, and at one point was estimated to cover over 70,000 acres and also coincided with a drought. Mortality was not reported during this outbreak.

If the outbreak continues, this survey suggests that branch dieback is more likely to occur in dense stands where ponderosa pine predominates, with trees largely in the 4-14 diameter classes.

MANAGEMENT ALTERNATIVES

The determination of appropriate environmentally acceptable, economically sound management strategies for Prescott scale requires a good understanding of desired future conditions and resource management objectives from a site specific as well as a landscape perspective. Alternative strategies for managing Prescott scale are summarized below. Keep in mind that proven strategies for managing this insect are unknown at this time. These alternatives represent our best professional judgement regarding current management strategies. Desired future conditions and resource management objectives for the area should dictate which alternative or mix of alternatives would be appropriate for each management area.

1. Do Nothing. Allow outbreak and branch dieback to subside naturally.

   Where applicable. This alternative may be desirable in areas where control measures cannot be undertaken, or where outbreak effects do not conflict with the development of desired future conditions.

   Effects. Outbreak would continue on its present course and eventually collapse naturally. Additional branch dieback and tree mortality may occur. Most trees with branch dieback will probably survive, however, some trees with severe branch dieback may be predisposed to attack by bark beetles. Trees that survive and sustain significant branch dieback may be deformed and show reduced growth for some time.

2. Silvicultural Treatment. Thin affected stands, favoring trees with little or no branch dieback. This could be done now or after the outbreak has subsided.

   Where applicable. This alternative may be useful where additional branch dieback or mortality would conflict with desired future conditions or resource objectives and where tree harvesting is allowed.

   Effects. This treatment would likely result in a thin from below, since the more severely affected trees are in the smaller diameter classes. Growth would be concentrated on the remaining larger trees. If a market is present for trees in these size classes, mortality would be captured. Theoretically, the more open stand condition may be less conducive to spread of the scale so if the thinning is conducted now it may have some effect on outbreak spread. Scale would be killed on felled trees since they cannot survive without their host.

3. Application of Pesticides. This alternative would involve application of pesticides to temporarily suppress populations of Prescott scale. The following materials may be appropriate for use on ponderosa pine: "dormant" or "superior" oil, acephate, carbaryl, diazinon, dimethoate, or malathion. The "dormant" or "superior" oil would be applied before buds break in the spring. Improper use of this material can lead to foliage injury (Cain et. al. 1990). The insecticidal sprays are used against the mobile "crawler" stage of the insect, therefore timing is critical and repeat applications may be necessary in the same year. Ground application of these materials would be the most appropriate method, in order to achieve adequate coverage of the pesticide. Applications of this type are costly in both time and money as each tree is treated individually.

Where applicable. Generally, applications of pesticides to control this type of insect would be reserved for very high value trees such as those in recreation areas or home sites.

Effects. Currently there is little information on the efficacy of these insecticides on Prescott scale populations. It is safe to say that some scale mortality would occur, but it is still uncertain whether this would benefit the stand as a whole. Pesticides can have a delaying effect on the "normal" population cycle in some cases by prolonging an outbreak. Pesticide alternatives must also take into consideration the possible negative effects to other portions of the ecosystem such as the surrounding watershed(s) and wildlife.

MANAGEMENT RECOMMENDATIONS

We would recommend a implementing a mix of option 1 and 2, leaving the decision as to where thinning is needed up to resource managers familiar with resource needs and objectives. Many of the areas surveyed were densely stocked and could benefit from a thinning from a growth standpoint anyway. It is our opinion that use of pesticides is not warranted in this case, given that this area is not a special area with high values associated with it.

TECHNICAL INFORMATION

The Prescott scale, Matsucoccus vexillorum Morrison, is a native insect found in ponderosa pine throughout the Southwest (Mackenzie 1943). Presence of this insect is seldom noticed, except when branch flagging (dieback) occurs. The most notable researched outbreak occurred around Prescott, Arizona during the 30's, lasting about 9 years and affecting 30,000 acres at its peak (Mackenzie et. al. 1948). Mortality rates were 1-2 percent. Branch dieback was noted primarily on trees less than 75 years old. At the same time outbreaks were also noted in New Mexico. Since that time outbreaks have been sporadic and localized (Furniss and Carolin 1977).

The Prescott scale has a 1 year life cycle (Mackenzie 1943). The most visible stage is the egg stage. Eggs are laid in masses in May and covered with a fluffy white wax. Egg masses look like tiny cotton balls, and are often found at branch nodes.

The three larval stages, which look like tiny black spheres, feed beneath scales at the bases of needles or bracts on 2 to 4 year old portions of twigs. The first stage larva, called a crawler, is motile and appears in May and June. These larvae are active but soon settle under the thin layers of bark on the stem or under the bracts enclosing the bases of the needles. Feeding begins at this time. The second stage larvae resemble the first stage and appear during July and August. These larvae may migrate a very short distance from their previous feeding spot before settling in a permanent feeding position, but often settle on practically the same spot. They show a preference for bracts enclosing the needle bases. Occasionally some are found in cracks and crevices of the bark layers. Winter is spent in the third stage, known as the preadult. This stage is apodous (lacking legs) and therefore not motile. It is during this stage that injury to the plant tissue beneath the feeding insect becomes most noticeable. However, it is not until later in the spring when the tree again becomes active that the injury becomes apparent and branch flagging occurs.

In April and May mature males and females emerge and mate. Females are flightless, while males may be capable of flight. Females do crawl, however, and may migrate several feet before finally settling down. It is thought that mating occurs during this migration period. They seem to prefer to settle at nodes, principally on the underside of the twigs. Soon after settling, females secrete wax profusely and extrude the eggs, completing the cycle.

The direct effect of scale feeding is the formation of lesions, necrotic areas, in the phloem. It is suspected that the insects produce a phytotoxic secretion or enzyme, while feeding, that is at least partly responsible for these necrotic spots (Mackenzie 1943). The insects feed by inserting their needle-like mouthparts, called stylets, into plant tissues and feeding on the sap of their hosts. A fungus, Cenangium sp., has also been found to be associated with the lesions on scale infested twigs. Mackenzie et. al. believed the scale to be the primary cause of lesion formation since lesions only occur on scale infested twigs, however, more work may be warranted in this area. Branch or twig dieback can also result from scale feeding. Cenangium sp. was also frequently observed fruiting on flagged twigs. Flagging most often occurs on younger trees, less than 75 years old (Mackenzie et. al. 1948) and is most conspicuous in dense stands. Both lateral and terminal shoots can be affected. Experimental work in the 1930's found evidence of an association between population density and branch dieback (Mackenzie et. al. 1948). When average population densities were greater than 100 scales per linear inch of stem, killing lesions resulted. Drought may also play a role, since many of the previous widespread outbreaks of branch dieback have occurred in association with deficit precipitation.

Factors associated with outbreaks of twig killing caused by these insects are not well understood. Drought has been implicated by some authors (Mackenzie et. al. 1948). There are no known relationships between flagging and tree vigor or site, however, this survey suggests that the role of tree density in branch dieback should be investigated. Mackenzie (1948) felt that the principal factor controlling populations was branch dieback. He found few natural enemies associated with the scale.

ACKNOWLEDGEMENTS

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PESTICIDE PRECAUTIONS

Specific chemical recommendations are given here with caution. Always check the pesticide label to be certain that a given chemical is registered for use on the site to be treated. Chemical registrations and use regulations frequently change. Contact the manufacturers for the most current product information, including supplemental labeling and special local needs regulations. It is a violation of federal law to use any pesticide in a manner inconsistent with its labeling. County Agricultural Agents, State Extension Specialists, and State and Federal Pest Management Specialists can be consulted for current information on available insecticides.

Trade names listed are given solely to provide specific information and are not intended as a recommendation, guarantee, or warranty of the product.

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TABLE 1. Ponderosa Pine Seedlings and Saplings Per Acre Infested or Killed by Prescott Scale on all Plots

DBH	Uninfested	Infested	Dead	Total
0	70.7			70.7
1	7.6			7.6
2	15.2	1.9		17.1
3	13.3			13.3
4	7.6	3.8		11.4
Total	112.5	5.7	0.0	120.1
	93.7%	4.8%	0.0%	

TABLE 2. Ponderosa Pine Trees per Acre Infested or Killed By Prescott Scale on all Plots

DBH	Uninfested	Infested	Dead	Total
6	16.8	33.6	2.8	53.2
8	22.4	32.0		54.4
10	13.0	22.0	2.0	37.0
12	14.7	12.6		27.3
14	5.0	6.0		11.0
16	4.8	1.6		6.4
18	2.1	0.3		2.4
20	2.7	1.5		4.2
22	1.8	0.6		2.4
24	1.8	0.2		2.0
26	1.2	0.4		1.6
28	0.3			0.3
30	0.8	0.1		0.9
32	0.4			0.4
Total	87.8	110.9	4.8	203.5
	43.1%	54.5%	2.4%	

TABLE 3. Ponderosa Pine Trees Per Acre by Diameter Class (DBH) and Scale Rating (SR) For All Plots

	Scale Rating					
DBH	0	1	2	3	4	Average
1	7.6					0.0
2	15.2					0.0
3	13.3					0.0
4	7.6	3.8				0.3
6	16.8	22.4		8.4	2.8	1.1
8	22.4	19.2	3.2	1.6	8.0	1.1
10	13.0	17.0	2.0	1.0	2.0	0.9
12	14.7	9.8	1.4		1.4	0.7
14	5.0	4.0	1.0	1.0		0.8
16	4.8	1.6				0.3
18	2.1	0.3				0.1
20	2.7	1.5				0.4
22	1.8	0.6				0.3
24	1.8	0.2				0.1
26	1.2	0.4				0.3
	0.3					0.0
30	0.7	0.1				0.1
32	0.4					0.0

Average SR for all trees = 1.0
Average SR for infested trees = 1.8

Table 4. Ponderosa Pine Trees Per Acre by Diameter Class (DBH) and Tree Condition For Plots Infested[1] With Prescott Scale

DBH	Uninfested	Infested	Dead	Total
6	19.2	57.6	4.8	81.6
8	13.5	54.0		67.5
10	13.6	37.4	3.4	54.4
12	8.4	21.6		30.0
14	3.6	10.8		14.4
16	5.6	2.8		8.4
18	1.0	0.5		1.5
20	1.6	2.0		3.6
22	0.4	1.2		1.6
24	1.2	0.3		1.5
26	0.9	0.6		1.5
28				0.0
30	0.4	0.2		0.6
32	0.2			0.2
Total	69.6	189.0	8.2	266.8
	26.1%	70.8%	3.1%	100.0

[1] 32 infested plots out of 54 total plots

Table 5. Ponderosa Pine Trees Per Acre by Diameter Class (DBH) For Plots Not Infested[1] With Scale

DBH	TPA
6	13.8
8	35.1
10	12.5
12	23.8
14	7.8
16	4.0
18	4.0
20	3.0
22	3.5
24	2.0
26	1.2
28	0.9
30	1.8
32	0.6
Total	114.5

[1] 22 uninfested plots

Table 6. Ponderosa Pine Basal Area Per Acre Infested or Killed By Prescott Scale on all Plots.

DBH	Uninfested	Infested	Dead	Total
6	3.3	6.7	0.6	10.6
8	7.8	11.1		18.9
10	7.3	12.2	1.1	20.6
12	11.7	10.0		21.7
14	5.6	6.7		12.2
16	6.7	2.2		8.9
18	3.8	0.6		4.4
20	5.0	2.8		7.8
22	5.0	1.7		6.7
24	5.0	0.6		5.6
26	3.3	1.1		4.4
28	1.7			1.7
30	4.4	0.6		5.0
32	2.2			2.2
Total	72.8	56.2	1.7	130.7
	55.7%	46.4%	1.3%	100.0%

Figure 1
Intensive survey area for Prescott scale
Fort Apache Indian Reservation, 1992

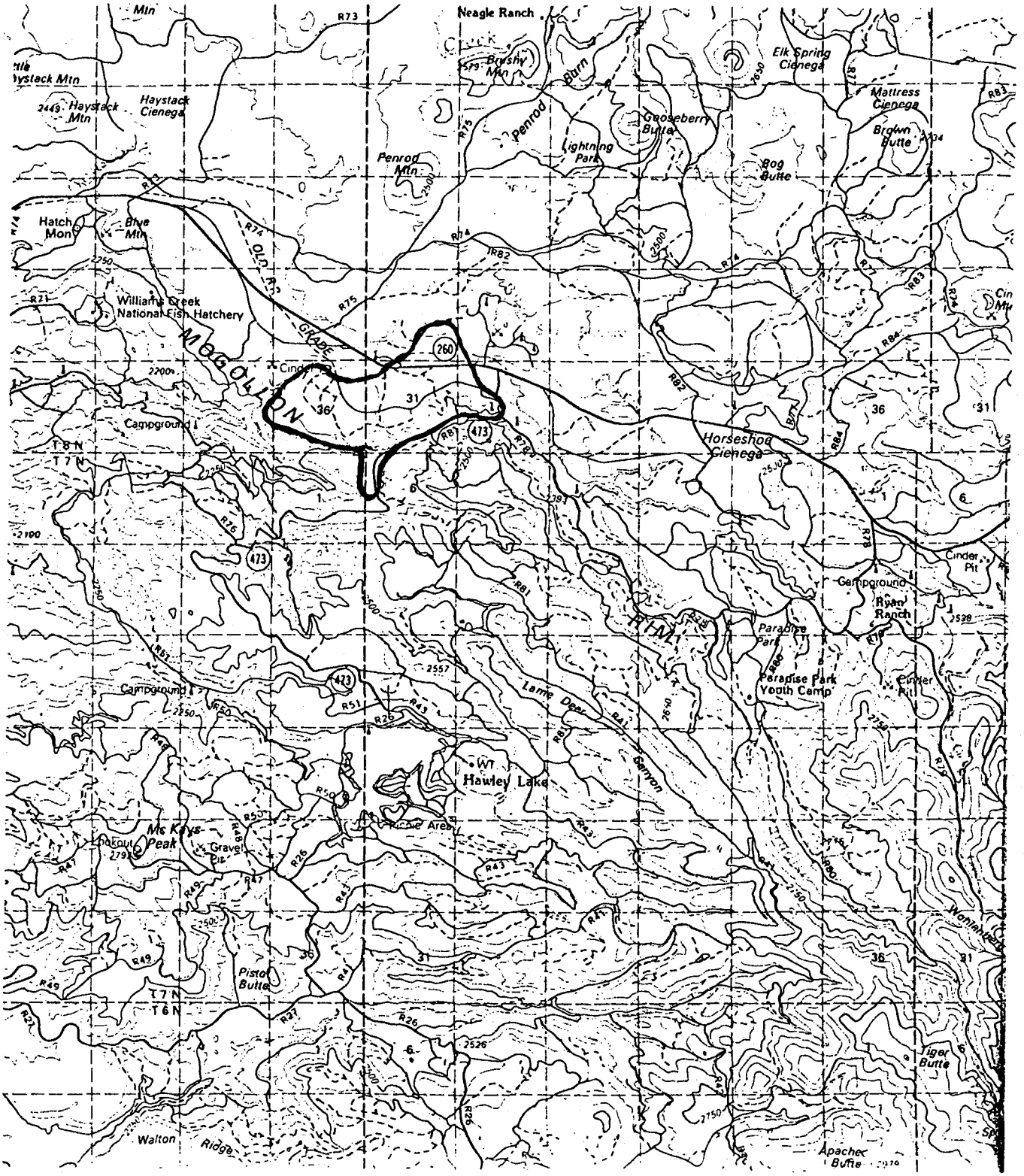

Figure 2

Extensive survey area for Prescott scale
Fort Apache Indian Reservation, 1992

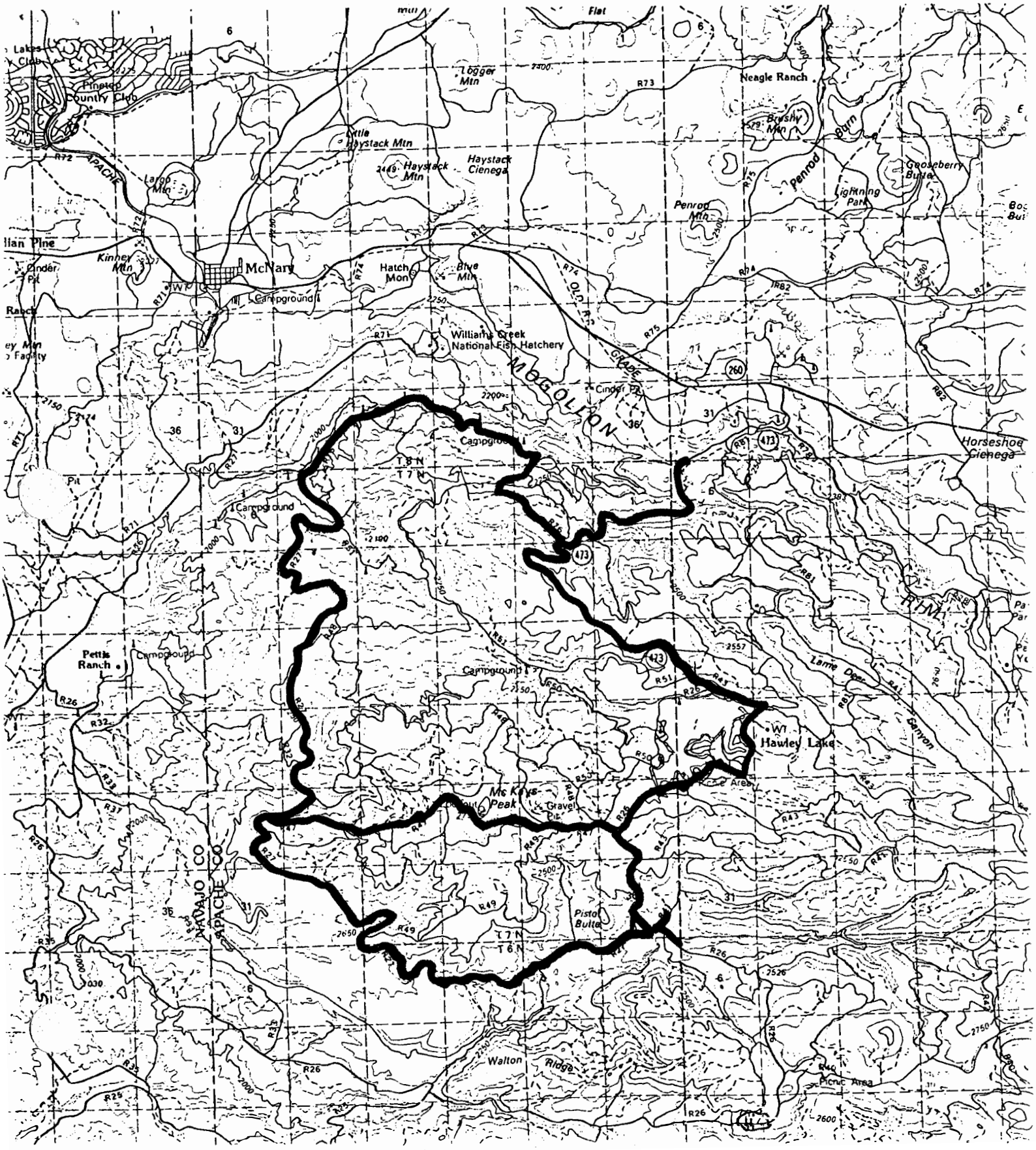

Figure 3

Distribution of branch dieback
observed during extensive survey
Fort Apache Indian Reservation, 1992